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ABSTRACT

Differences found in men's and women's attitudes towards mathematics, and differences in demonstrated abilities and experiences in mathematics classes are detailed. The sample used includes 479 pupils from 22 classes in 11 urban and suburban schools, with approximately 49% of the students female. The instruments used to collect data included survey reports, questionnaires, interview guides, tests, rating scales, and observation instruments. The survey report, questionnaires, and interview protocols were developed and pilot-tested within the study. The factor most often found to differentiate the students continuing in mathematics from those who are not, identified from the student questionnaire, student ratings and test data, is parental expectations and support in taking advanced mathematics. The data suggest that parents are perhaps the most important factor for women as well as men in continuing their studies. Further, women who planned to continue in mathematics studies had more spatial ability, more positive feelings about mathematics, less anxiety, and did not perceive mathematics as a male domain. The results suggest that parents should be made more aware of their influence in their children's decision-making processes. It is felt the findings should be made available to inservice teachers, school counselors, and parent groups. (MP)

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SRI International

COMPARISON OF MEN'S AND WOMEN'S BEHAVIORS IN HIGH SCHOOL MATH CLASSES

Jane A. Stallings, Ph.D.

Presented to:

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INTRODUCTION

Recognizing that women historically have been underenrolled in advanced math classes and thus underrepresented in math-related occupations, SRI International has carried out a study to examine factors that influence women's decisions to take advanced math classes. The study was funded by the National Institute of Education in order to obtain a better understanding of women's involvement in mathematics. SRI was one of 10 organizations funded to conduct research under this program.

The primary focus of SRI's Women and Math study was to identify factors that promote higher enrollment and encourage more positive attitudes toward mathematics among high school women. Specifically, the study was designed to (1) identify major personal, social, and school-related factors that influence student decisions to enroll in advanced math courses, and (2) to identify math programs or career education programs that promote high enrollment of women in math courses. These factors were investigated as possible determinants of student attitudes, perceived utility of mathematics, and future enrollment in math courses.

Data were collected from 11 schools (four urban and seven suburban) with high, medium, and low enrollment of women in advanced math classes. Over 2,100 math students, 76 teachers in 91 classrooms, and 53 counselors in the Bay Area participated in the study.

Through our design and observation methodology, we identified some classroom instructional processes that are used differently with men and women. Through questionnaires and interviews we examined how women's decisions regarding enrollment in math classes are influenced by peers, parents, teachers, and counselors.

The purpose of this paper is to detail the differences we found in men's and women's attitudes toward mathematics, and the differences in their demonstrated abilities and experiences in math classes.

STATEMENT OF THE PROBLEM

Women account for 49% of the secondary school population in the United States, but comprise only 20% of high school students taking courses in advanced mathematics. Furthermore, while women comprise 45% of the total college and university population, they constitute only about 30% of the college and university students receiving Bachelor degrees in mathematics. The underrepresentation of women in advanced math courses is significant enough to suggest a problem. When considered in the context of occupational data, the facts pertaining to women's nonelection of advanced math courses take on even broader significance. Women represent about 47% of the U.S. labor force and account for 42% of those engaged in professional occupations, but they account for only 12% of the scientific or technical careers.*

If one assumes that the nonelection of advanced math courses greatly reduces the possibility of entering certain scientific or technical programs of study at the undergraduate and graduate level, then one may also assume that underrepresentation of women in advanced math courses is related to the number of women in scientific or technical careers. Simply stated, career options for women may be severly limited by the decision not to pursue the study of mathematics beyond that which is required to earn a high school diploma.

The statistics cited above suggest the scope and nature of the problem; they do not, however, account for the reasons that precipitated it. It is not known if the problem exists because the field of mathematics has become sex-stereotyped and such stereotypic values are somehow transmitted to women during their early interactions with school and other cultural institutions. The socialization process experienced by

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*National Center for Educational Statistics (1973 data) and Bureau of Labor Statistics (1977 data).

most women may convey the message that careers requiring an extensive background in mathematics are "masculine domains." The nature of such sex bias, the way in which it is transmitted, and the manner in which it impinges on women's decisions to take advanced courses in mathematics are issues addressed by this study.

Within the American cultural ethos there are numerous possible sources of sex bias which, singly or in combination, may account for this phenomenon. Schools, parental interactions, and peer relationships all possess the inherent capability for transmitting sex bias. Because all of these influences are interactive and may operate within a framework of shared values and goals, it is likely that sexist values are transmitted and reinforced.

If schools are considered as primary socializing institutions where key cultural values are transmitted to students, it follows that sexist beliefs may also be conveyed to students. Within the school these sex-stereotypic values in relation to mathematics and careers may be transmitted in several ways:

- Teachers, both in the area of mathematics and other subjects, may transmit sex bias in their instructional behavior. Whether through explicit statements or implicit behavioral cues, whether consciously or unconsciously, teachers may instruct male and female students differently. In the conscious and explicit mode, for example, teachers may use different criteria for assessing the progress of men and women students; or they may make statements which convey the belief that "mathematics is not a suitable subject for women." In the unconscious and implicit mode, teachers may respond differently to questions posed by male students than they do to questions raised by female students; they may be more willing to spend time "rapping" after class with men students than with women, or they may advise men and women differently on whether to take more advanced math courses.
- Counselors may be critical influences in students' selection of courses. Thus, they must be considered as potential sources for the transmission of sex values in relation to mathematics and careers. Male and female guidance counselors may provide advice on the basis of the sex of the students with whom they are interacting. It is possible, for example, that counselors perceive mathematics and careers related to mathematics in a sex-stereotypic manner and that they advise men and women students on the selection of advanced math courses accordingly.

- School administrators, while they do not as a rule interact with students on a frequent basis, may hold sexist attitudes regarding mathematics that they transmit in shaping school-related instructional policies. Biases could be reflected in career education programs that expose women to a wide range of nonmath-related careers while exposing men to math-related careers. Professional women invited to speak on career days may or may not be from math-related occupations. To the extent that administrative sanction is required for extracurricular activities within the school, administrators may discourage activities intended to remediate sex bias, such as clubs for women students or consciousness-raising groups. They may or may not invite women professionals to address school assemblies or to speak with students during a school activity, such as career day. Finally, administrators may act in implicitly sexist ways by hiring only male math teachers or assigning male teachers or counselors to more responsible positions.

This brief description of potential sources of sex bias in the school setting suggests that many of women's decisions regarding the pursuit of advanced math courses may be explained by school-related factors. The relationship of high school students to their parents can also influence students' decisions relating to course selection and career options. Parents may serve implicitly as sex-role models and as the transmitters of explicit values which indicate to daughters that they should or should not pursue various courses of study. Such related factors as the occupations of the father and mother and parental socio-economic status most likely convey strong messages about "acceptable" courses and careers.

Sex bias transmitted by school and parents may be reinforced or counteracted by peer influence If, for example, in a given school, the percentage of girls enrolled in advanced math courses is fairly high, women students facing the critical decisions as to whether to take advanced courses may feel comfortable in electing to take them. Conversely, in a school with low female enrollment in such courses, or in cases in which friends elect not to take such courses, women students may elect not to undertake additional work in mathematics. Peer groups can exert more subtle influences as well. It is also possible that the interaction of women students with each other is characterized by the same sex-role behavior as that promulgated by the school and parents.

The interaction of men and women students may further serve to reinforce sexist values relating to the study of mathematics and selection of careers.

The ethos of American culture must also be considered as a potential source of sexist values that have a significant impact on women's decisions in relation to advanced mathematics. The transmission of sexist values may have a cumulative effect on women which, when considered in the context of other influences converging upon them, may further discourage them from electing to pursue courses in mathematics beyond those required. For example, the "woman-as-homemaker" image portrayed by television cannot help but affect the self-perception of young women belonging to a generation of television watchers. This stereotypic image of women no doubt perpetuates the traditional attitude that regards women as objects to be cherished and protected, not as individuals who question and probe.

The problem of women's underrepresentation in advanced math courses and scientific or technical careers no doubt has multiple antecedents, all of which interact. It is the intent of this study to define and describe the several influences impinging on women's decisions regarding whether to pursue advanced courses in mathematics, to analyze the interrelationships among these forces, and to identify ways in which each of these forces contributes to a decision concerning the further study of mathematics.

REVIEW OF RELATED RESEARCH

The most serious problem facing those concerned with equity in math education is ensuring that women continue their study of mathematics (Fennema, 1976). Recent studies have attempted to identify factors influencing the decision of women to continue their math education. The results of most of these studies, which are primarily cross-sectional, are inconclusive due to a failure to control for relevant variables or inadequate research design and analysis. In a review of 36 studies on the sex-related differences in math education. Fennema (1974) argues that those studies should have controlled for two confounding effects. First, more lower-ability men than women students drop out of high school, resulting in a more homogeneous sample of men. Second, the women students who do elect math courses appear brighter than those who do not, thus creating a lower-ability sample of women students not taking mathematics.

Clearly, a carefully designed, systematic study of women's participation in mathematics at the secondary level is needed to determine why fewer women than men enroll in math courses. Factors that are considered in this paper include:

- Sexual stereotyping of mathematics as a male domain.
- Perceived utility of math courses.
- Peer influence.
- Parental influence.
- Difference in math aptitude and achievement of men and women.
- Math-related school programs and counselor advice.
- Sex-related attitudes of math teachers toward male and female students in classrooms.

Sexual Stereotyping of Mathematics as a Male Domain

In the high school years, both men and women were found more likely to perceive mathematics as a male domain (Ernest, 1976; Fennema and Sherman, 1977b). There appears to be no significant difference between the sexes in terms of liking the subject (Ernest, 1976; Aiken, 1976; Fox, 1974b; 1975a).

Women's low math self-concept may be a result of the sexual stereotyping of mathematics as a male domain. Women tend to underestimate their intellectual abilities (Maccoby and Jacklin, 1974) and feel inadequate in many kinds of problem-solving activities (Kagan, 1964). This lack of self-confidence results often in mathematical anxiety (Ernest, 1976; Fennema and Sherman, 1977b; Donady and Tobias, 1977; Tobias, 1976; Levine, 1976). Even though women's low math self-concepts tend to decrease with age, Fennema (1974) found low self-concepts among women who were achieving better than men.

Perceived Utility of Math Courses

A woman's perception of the usefulness of mathematics to her future activities is likely to affect her participation in math courses. Much of the literature suggests that women in high school feel that their roles as wife and mother preclude involvement in a traditionally male-dominated occupation. Hawley (1971) found marriage to be one of the primary goals for most high school women. Astin (1974a) concluded that if a woman anticipated a conflict between her roles as homemaker and career woman she would give up her career. Fennema and Sherman (1977b) hypothesized that women do not see mathematics as an appropriate activity and do not recognize its usefulness in their career plans. In a study of 881 men and 878 women in secondary schools, Hilton and Berglund (1974) found that men perceived mathematics as more likely to be helpful in earning a living than did women. However, the Fennema and Sherman study did not find as great a difference between men's and women's beliefs as was found in the Hilton-Berglund study. It is suggested by Fennema and Sherman that this discrepancy in findings may indicate that the beliefs

of women are becoming more similar to men in this respect. Fox (1976) attributes the difference in the perceived usefulness of mathematics to women's lack of orientation to careers other than homemaking, interests in fields other than mathematics and science, and unawareness of the relevance of mathematics and science to technical professions.

Peer Influence

Numerous studies show that peers exert a strong influence on adolescent attitudes and behavior (Coleman, 1961; Cusick, 1973; Rigsby and McDill, 1972; Hauser, Sewell, and Alwyn, 1976). Little research, however, has specifically examined the influence of peers on the decision of women to study mathematics. The few studies that do exist point to students' stereotypes about appropriate sex-linked behavior as an important agent of peer pressure. Matthews and Tiedeman (1964) reported that a decline in career commitment by women of high school age was related to perceptions of male classmates, and disapproval of the use of female intelligence. Many researchers have reported that women are reluctant to continue with mathematics due to fear of social recrimination (Casserly, 1975; Fennema and Sherman, 1977b; Fox, 1976; Levine, 1976; Solano, 1976). In an effort to encourage higher enrollment of women in math classes, all-women math classes have been introduced as an intervention strategy with varying degrees of success (Fox, 1974a; Hawley, 1971). A more acceptable alternative, early tracking of women in academic programs, has been recommended (Casserly, 1975; Fox, 1976; Haven, 1971; Sells, 1978a).

Parental Influence

Students may also be influenced by parents who hold sex-stereotypic views of women in mathematics. Fennema and Sherman (1976, 1977a) showed that student reports of parental perceptions of the child as a learner of mathematics reflected sex differences. Researchers argue that parental encouragement of women to enroll in advanced mathematics is a crucial but often absent influence (Aiken, 1972a; Haven, 1971; Fennema and Sherman, 1977a; Poffenberger and Norton, 1956). Block (1973) found that

parents stress interpersonal relations and affection with their daughters whereas they emphasize achievement, competition, and control of feelings with their sons. Fathers were found to help more in mathematics homework in the higher grades than did mothers (Ernest, 1976). Levine (1976) reported that mothers accepted low math achievement from their daughters because of their own lack of ability in mathematics. The mothers' low math self-concepts may explain their reluctance to help with math homework. Parents report buying more scientific games and toys for sons (Hilton and Berglund, 1974; Maccoby and Jacklin, 1974) and offering more rewards and reinforcements to their sons to learn mathematics than to their daughters (Astin, 1974a).

The literature also suggests that parents hold lower educational and vocational aspirations for their daughters than for their sons. Fox (1975b) found that more men than women perceived their parents as favoring acceleration in mathematics. Casserly (1975) found that parents do not expect their daughters to achieve as much as their sons. It has also been found that daughters who identify with their fathers, or who have working mothers, tend to enroll in higher level math courses (Astin, 1974b; Astin, Harway, and McNamara, 1976).

Differences in Math Aptitude and Achievement of Men and Women

It has been generally accepted that there are sex differences on math achievement tests (Aiken, 1976; Astin, 1974b; Fox 1975a; Maccoby and Jacklin, 1974). Fennema and Sherman (1977a) have found minimal sex-related differences in math achievement in grades six through nine, and in half of the high schools studied men achieved at higher levels than women. Studies have also indicated trends for men to perform better on higher level cognitive tasks (Fennema and Sherman, 1977a). Stafford (1972) suggests a hypothesis that a sex-linked recessive characteristic is the cause for this difference.

An area of intellectual development most often related to math learning is spatial visualization. Women have been reported to perform lower than men on spatial visualization tests (Fennema, 1974; Maccoby

and Jacklin, 1974). Sherman and Fennema (1977) have found that men are not invariably superior in math achievement and spatial visualization. They suggest the influence of sociocultural factors to be highly important concomitants of sex-related differences.

The inconclusive and inconsistent findings for sex differences in math achievement and aptitude may be due to the failure to control for differential course taking (Fennema and Sherman, 1976, 1977a, 1977b). It is hypothesized that the best predictors of success in mathematics are previous math learning and intelligence tests. The number of women who have equal capability with men for learning high school mathematics is larger than the number of women who elect to study mathematics, and this difference is reflected in past reported studies. The results of the two national studies that claim higher achievement for men, Project TALENT (Flanagen, 1976) and the National Assessment of Educational Progress (Mullis, 1975), merit the same criticism because they failed to control for educational or mathematical background. Fox (1975b) and Astin (1974b), however, have found large sex differences in favor of men among gifted students as early as grade seven.

Math-Related School Programs and Counselor Advice

Few studies can be located that focus to any extent on the overall setting in which secondary school instruction in mathematics takes place. Little reference is found in the literature to such potentially significant factors as administrative support for increasing women's enrollment in mathematics, organizing school programs to facilitate increased enrollment by women in math courses, or provisions of informational materials to increase awareness of the potential value of math courses.

Occasional references to the value of role models in stimulating interest of women in the math field appear in the literature. In a review of National Science Foundation projects, Lantz, West, and Elliott (1976) report that role models were the most significant factor affecting women's enrollment in mathematics in some of the projects studied.

Prediger, McClure, and Noeth (1976) found role models in mathematics to be more successful than those in other informational careers in science and technology.

Two highly visible role models in the school setting are the teacher and the counselor. The influence of the teacher will be discussed in the next section. Fox (1976) reported that counselors are seen as the least potent influence upon the child. Still, women are more likely to seek advice from counselors than men (Harway et al., 1976), particularly regarding advanced math courses (Haven, 1971).

A few counselors have actually admitted discouraging women students from taking advanced math courses (Casserly, 1975; Luchins, 1976). This discouragement or lack of encouragement may be a reflection of the counselor's biases. Schlossberg and Pietrofessa (1973) found that one of the major determinants of a counselor's advice concerns the opinion of what behavior is appropriate for women in society. Thomas and Stewart (1971) showed that both men and women counselors rated traditionally feminine career goals of women students as more appropriate than traditionally masculine career goals. Schlossberg and Pietrofessa (1973) observed interviews of counselors and women students concerning the decisions to major in engineering and discovered that more than three-fourths of the statements made by the counselors of both sexes were biased against the choice of the engineering major.

The counselors' stereotypical attitudes are reported to be decreasing during the present decade (Englehard, Jones, and Stiggens, 1976). MacDonald (1978) and Ernest (1976) have recommended that counselors increase math awareness by beginning career education programs early, upgrading existing career education programs, and counseling students to continue their math training.

Sex-Related Attitudes of Math Teacher and Treatment of Male and Female Students in Classrooms

The literature on teacher expectations for pupil behavior suggests that differential expectations for men and women students may be a

factor in the low enrollment of women in math courses. Many of the more recent studies on teacher attitudes toward mathematics involved prospective teachers for the elementary level. Ernest (1976) reported that 41% of the teachers he studied felt men did better in mathematics, while none felt women did better. Teachers also appear to have more negative perceptions of mathematically gifted women (Solano, 1976), and in fact can be hostile (Fox, 1974a, 1975a).

Although teacher/student interaction is believed to be an important factor in the decision of women to enroll in math courses, few classroom interaction studies focusing on differential treatment and response by sex can be found. Sears and Feldman (1966) found that in the 76 studies reporting classroom observation in the Handbook of Research on Teaching (Gage, 1963), not one indicated to whom--man or woman--the teacher behavior was directed. In the Second Handbook of Research on Teaching (Travers, 1973) we noted this same missing treatment in the reported observational studies. These authors did recognize, however, the need for future research studies to allow for individual differences. Aiken (1972) reported on more recent investigations pertaining to the importance of verbal factors in the learning of mathematics. Much of the research conducted to date on teacher/student interaction has involved samples at the elementary level (Meyer and Thompson, 1963; Spaulding, 1963; Fey, 1969). In one of the few classroom interaction studies at the secondary level, Bean (1976) showed that teachers initiated more contacts with men students than with women students, although no corresponding sex differences were found in the number of student contacts with the teacher. Other researchers have supported these findings (Good, Sikes, and Brophy, 1973). A study by Dweck and Repucci (1973) suggests that math teachers provide different feedback to men than to women when the students give a wrong answer. Men are told to try harder; women are praised for even trying. Future research is needed to determine specifically whether secondary school teachers tend to expect higher achievement in mathematics by men than women and whether teachers differentiate between the sexes in rewarding math achievement.

SAMPLE AND INSTRUMENTS

Sample

The sample of students used for this study includes 479 geometry students located in 22 classes in 11 urban and suburban schools. Approximately 49% of the geometry students were women.

Instruments

To collect data that would allow an examination of the many factors that might influence women's decisions to enroll in advanced math classes, a variety of instruments were used. These included: survey reports, questionnaires, interview guides, tests, rating scales, and observation instruments.

A telephone survey report was used to select the sample of schools with high and low enrollment of women in advanced math classes and to identify schools with high and low intensity math-related career information programs. Information on students was collected by four instruments: a student questionnaire, a student interview guide, a space relationships test to assess math aptitude, and a math criterion-referenced achievement test. The student questionnaire and interview protocols were used to assess students' decisions to enroll in math classes. Teacher and classroom data were obtained from three sources: a teacher questionnaire, a Student Rating Scale of Instructors, and the SRI Secondary Observation system.

The testing instruments and the Student Rating Scale of Instructors have been used in previous studies in secondary schools and required no adaptation for this study. The SRI Classroom Observation Instrument required slight modifications. The survey report, the questionnaires, and the interview protocols were developed and pilot-tested within this study.

Student Questionnaires

Seven domains were assessed by the questionnaire. They were: students' attitudes toward mathematics, prior experience in mathematics, perception of parents' attitudes, opinions of teachers, counselors, and school programs in regard to mathematics, and estimates of peer influence.

Student Interviews

The chief advantage of utilizing questionnaires is that they are easy to administer and they provide data that can be analyzed reasonably quickly. The primary disadvantage of questionnaires is that their format precludes the possibility of in-depth probing. To overcome this inherent drawback of questionnaires, student interviews were conducted with a stratified subsample of students, both men and women. The interview subsample was stratified by sex and by students' decisions to pursue or not to pursue additional math courses. The intent of the interviews was to collect comprehensive data regarding why students decided to pursue or not to pursue advanced courses in mathematics. Within the context of the interview, data were collected regarding students' perceptions of those factors that influenced their decisions.

The interview protocols call for probing into areas such as how the student likes the school, how they like math classes, and how they feel about what they are learning in math classes. If they did not like mathematics, we asked when they started to feel that way. Most of the probes were based on the answers students had given on the questionnaire. Although the interviews were highly structured, the protocols permitted interviewers ample opportunity to probe for responses in areas of interest to this study. For the most part, the interview protocol was close-ended, permitting the interviews to be conducted during no more than 30 minutes.

Student Rating Scale of Instructors

Instructional processes were assessed through the Student Rating Scale of Instructors. This rating scale allows us to examine students' subjective viewpoints of certain aspects of classroom processes. This rating scale was developed in 1973 by the staff of the Sequoia High School District in California and has been used in secondary classrooms in that district. The rating scale allows the student to select on a five-point scale a rating number that, in the student's opinion, best describes an instructor in areas such as clearness of course objectives, clearness of assignments, fairness in grading, classroom control in discipline, preparation for the class, communication, friendliness, course content, helpfulness, participation, and encouragement of independent ideas. Four scales are obtained from the Student Rating Scale of Instructors. Each scale can be used in analysis to describe the student's perception of the instructor.

SRI Secondary Observation Instrument

In order to examine classroom processes that might enter into the decisionmaking process, the SRI Secondary Observation Instrument (SOI) was used. This instrument was based on an observation system developed at SRI for use in secondary reading classrooms. Modifications were made that would allow observers to record events that occur in senior high math classes and to identify whether a teacher was interacting with a male or female student.

The SOI contains three sections. The first section, Identification Information, identifies the schools, teachers, classes, the number of adults, and male and female students present in the classroom.

The second section is the Classroom Snapshot. The Snapshot is a matrix that yields data about the activities of each adult and student in the classroom, the size of the group, and the materials being used. From this record, information is obtained on how the teacher spends his or her time and with whom, how the aides spend their time and with whom, and how often the students operate independently and in what activities.

This record is made five times during a class period. Three days of observation produced 15 snapshots for each class observed.

The third section, the Five Minute Interaction (FMI), is used to record the teacher's verbal interactions or nonverbal behaviors. It consists of a series of frames in which each behavior/interaction is recorded in the four categories provided: Who, To Whom, What, and How. Consecutive frames can record 72 continuous interactions during a 5-minute period. Five of these 5-minute interactions are recorded during one class period. Over the 3 days of observation, this provided 15 5-minute interactions and an approximate 900+ interaction frames, for each class.

Adaptations in the coding system allowed us to answer questions such as:

- When the teacher asks questions of the entire class, who volunteers answers more often--male or female students?
- When the teacher calls on a specific student, it is more often a male or female student?

Math Criterion Tests

It is quite possible that math achievement and/or math ability, real or perceived, will have a strong impact on whether a student enrolls in advanced math courses. In order to examine this area, math criterion tests were administered to all students participating in the study.

Rather than developing math criterion tests for all levels of classes involved in this study, SRI used an established battery of tests recommended by math department chairpersons at several local schools: the Cooperative Mathematics Tests developed by Educational Testing Service and published by Addison-Wesley. Separate tests were given at the following levels: general math (arithmetic), first-year algebra, geometry, second-year algebra, trigonometry, analytical geometry, and calculus.

Space Relations Test

To examine math aptitude, the Space Relations Subtest was used. This subtest (from the Differential Aptitude Tests, developed by George K. Bennett, Harold G. Seashore, and Alexander G. Wesman), published by The Psychological Corporation, has been described by past reviewers as the best available instrument of its kind. Significantly for this study, separate norms are available for males and females.

ANALYSES AND RESULTS

Three analyses are presented here. The first describes classroom interactions, the second compares men's and women's scores on an achievement test and a spatial ability test, and the third compares factors relating to students' decisions to enroll or not to enroll in advanced math classes.

Are Men Treated Differently Than Women in Geometry Classes?

Because there are approximately 50% women in geometry classes, the number of teacher interactions with men and women should be about equal if equal treatment is being given. Table 1 displays the average frequency of observed interactions of teachers with male or female students during a geometry class period. These computations are based on the total 22 geometry classes in the study.

Though few of the differences are statistically significant, the trend is rather clear. Men are spoken to more often than are women (F10, F11). Men ask more questions (F15, F16) and teachers ask men more questions (F18, F19). Women volunteer answers as often as do men (F34, F35) but the men are called upon to respond more frequently than are women (F40, F41). Men receive a little more individual instruction (F43, F44) and social interaction (F54, F66). Acknowledgment (F62, F63), praise (F65, F66), encouragement (F80, F81) and corrective feedback (F100, F101) are given slightly more frequently to men than to women.

The only variable that occurs more frequently with women is positive interactions (F104), i.e., teachers smile or laugh more with women students than they do with men.

Overall, men students are treated somewhat differently than are women students in geometry classes. This is in agreement with Bean's finding (1976) that showed teachers initiating more contacts with men students than with women students and with Dweck and Reppucci (1973) who suggest that math teachers provide more feedback to men.

Table 1

MEAN FREQUENCIES OF INTERACTION VARIABLES
FOR 22 GEOMETRY CLASSES*

Variables		$\bar{x}$
F10	All interaction/female student-teacher verbal, math	38.69
F11	All interaction/male student-teacher verbal, math	46.88
F15	Female student question/math	5.60
F16	Male student question/math	6.59
F18	Teacher question/female student/math	3.72
F19	Teacher question/male student/math	4.60
F34	Female volunteer responses to teacher/math	1.23
F35	Male volunteer responses to teacher/math	1.67
F40	Teacher response/female student question/math	5.49
F41	Teacher response/male student question/math	6.32
F43	Teacher instruction/female student/math	5.48
F44	Teacher instruction/male student/math	6.56
F54	Teacher social interaction/female students	0.97
F55	Teacher social interaction/male students	1.41
F62	Teacher acknowledge female students/math	2.87
F63	Teacher acknowledge male students/math	3.59
F65	Teacher praise female student/math	0.26
F66	Teacher praise male student/math	0.34
F80	Teacher encouraging female student/math	0.23
F81	Teacher encouraging male student/math	0.26
F88	Interaction teacher-female student/relevance of math	0.00
F89	Interaction teacher-male student/relevance of math	0.07
F100	All corrective feedback/female students/math	8.03
F101	All corrective feedback/male students/math	10.13
F104	Teacher positive interaction with female students	0.41
F105	Teacher positive interaction with male students	0.40
F111	Teacher negative interaction with female student	0.06
F112	Teacher negative interaction with male student	0.14

*50% women in classes.

Are There Differences Between Men and Women in Math Aptitude and Achievement?

To examine the relationship between math aptitude and math achievement, correlations were computed for each level of math test with the space relationships test. The results of these computations are presented in Table 2. There are significant correlations for men and women between spatial ability and math achievement above the level of arithmetic. There are significant correlations for women at all levels but curiously not for men in either algebra II or calculus.

Table 2

CORRELATION OF SPACE RELATIONSHIPS AND ACHIEVEMENT TESTS

		Overall		Men		Women	
Tests	N	r	p	r	p	r	p
Calculus	81	.02	--	.17	--	.57	.01
Analytic Geometry	69	.68	.001	.70	.001	.60	.001
Trigonometry	206	.38	.001	.27	.01	.50	.001
Algebra II	275	.15	.01	.05	--	.24	.01
Geometry	471	.53	.001	.49	.001	.52	.001
Algebra I	281	.49	.001	.50	.001	.45	.001
Arithmetic	153	.11	--	.20	--	.03	--

Clearly there are relationships between spatial ability and math achievement. Similar to the findings of Fennema (1974) and Maccoby and Jacklin (1974), we found men generally score higher on the space relationships test. We also found that women continuing in math studies scored higher on the space relationships test than did women who did not continue.

Women scored higher than men in arithmetic, and did as well as men in algebra II and trigonometry. Even though men were superior in four out of seven tests, these results tend to support the findings of Sherman and Fennema (1977) that men are not invariably superior in math achievement or spatial visualization when the number of math courses and the nature of the courses taken are considered (see Table 3).

Table 3

MEANS AND STANDARD DEVIATIONS OF MEN AND WOMEN ACHIEVEMENT TEST SCORES AND SPACE RELATIONSHIPS SCORES BY COURSE LEVEL

	Achievement Test			Space Relationships Test	
Course	N	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Calculus					
Men	58	10.7	3.28*	26.06	3.59
Women	23	8.78	3.94	24.26	4.75
Analytical Geometry					
Men	37	11.51	3.66*	23.70	5.69
Women	32	9.25	3.94	19.96	6.37
Trigonometry					
Men	106	7.94	3.57	23.72	5.47
Women	100	7.78	3.51	22.58	5.93
Algebra II					
Men	149	12.95	5.49	24.25	4.98*
Women	126	12.71	5.53	21.91	5.21
Geometry					
Men	248	15.99	3.08*	23.03	5.52*
Women	223	14.75	3.74	20.65	5.76
Algebra I					
Men	136	12.81	3.86*	20.32	5.95*
Women	146	11.88	3.97	17.42	6.34
Arithmetic					
Men	70	4.00	1.69*	14.48	5.54
Women	83	4.53	1.64	13.72	4.57

*$p < .01$

Overall, men scored higher than women on the achievement tests except in trigonometry, algebra II and arithmetic (see Table 3). However, women continuing in math did not perform less well on the geometry achievement test than did men continuing in math.

Why Do Students Enroll or Not Enroll in Advanced Math Classes?

Because the focus of this study is on students' decisions to take advanced mathematics, we limited our analysis of this question to 22 geometry classes located in the 11 schools. The reason most often given by men and women taking algebra I and geometry was to meet university requirements. Thus, the most pertinent question is why they continue math studies beyond geometry. In order to study this question we had to know which students were continuing in math studies.

Table 4 shows the contrasts of men and women who are presently enrolled in geometry who intend to take more advanced mathematics. These data indicate that of the 489 students taking geometry who completed the questionnaire, 49% were women. Of that 49%, approximately 78% were planning to continue with mathematics. Although there is about an equal number of women as men taking geometry, twice as many women as men do not plan to continue in math studies. To examine the different responses given by men and women for continuing, variables were used from the student questionnaire, Student Rating Scale of Instructors, space relationships test, and the geometry achievement test. Student interviews were used to document in more detail the possible school influences.

Table 4

PERCENTAGE OF MEN AND WOMEN CONTINUING WITH ADVANCED MATHEMATICS

	Number Presently Enrolled	Continuing in Math (%)	Not Continuing (%)
Women	231	78	22
Men	258	89	11

Men Continuing Compared with Women Continuing

Through a discriminant function analysis substantiated by analyses of variance, significant differences were found in the following factors influencing the continuation of women and men: The men who were continuing reported more parent support of taking advanced mathematics and their parents had higher expectations. Women reported speaking less often to their math teachers and feeling less anxiety about mathematics than did the men. Men continuing scored higher on the spatial ability test but did not score higher on the geometry achievement test than did women continuing (see Table 5).

Table 5

A COMPARISON OF WOMEN AND MEN GEOMETRY STUDENTS IN 11 SCHOOLS WHO ARE CONTINUING IN MATHEMATICS*

Variable of Interest†	Women Continuing N=189 $\bar{x}$	S.D.	Men Continuing N=230 $\bar{x}$	S.D.	Contrast p Value
Talk to math teacher	1.42	2.13	3.39	6.20	.06
Spatial ability	21.10	5.60	22.45	5.52	.06
Math anxiety	.46	.40	.50	.43	.04
Father support for taking mathematics	.94	.18	.98	.04	.10

*All contrasts significant at $\alpha \leq .10$ are reported. These are contrasts of interest; they are not to be reported as significant at .1 as we are doing multiple tests.

†These variables comprised the discriminant function that identified factors which differentiated between continuation and no continuation. This is an analysis of variance on those factors.

Women Continuing Compared with Women Not Continuing

When women who were continuing in math studies were compared with women who were not, five principal factors emerged: teachers, experience, ability, parents, career plans (see Table 6). Those continuing in math

Table 6

COMPARISON OF WOMEN WHO ARE CONTINUING MATH STUDIES WITH THOSE WHO ARE NOT (For all geometry classes across all 11 schools)*

Variable of Interest†	Women Continuing N=189 $\bar{x}$	Women Continuing N=189 S.D.	Women Not Continuing N=42 $\bar{x}$	Women Not Continuing N=42 S.D.	Contrast p Value
Would not take a mathematics class from a teacher they didn't like	1.60	.49	1.75	.43	.06
No preference regarding sex of teacher	.29	.43	.15	.50	.07
Rate teacher professional	32.80	4.80	30.60	5.90	.03
Difficulty with mathematics	.58	.48	.77	.41	.02
Math anxiety	.46	.40	.73	.44	.001
Space relationships test	21.10	5.60	19.10	5.60	.03
Father support for taking mathematics	.94	.18	.88	.33	.04
Mother support for taking mathematics	.98	.13	.93	.26	.04

*All contrasts significant at $\alpha \leq .10$ are reported. These are contrasts of interest; they are not to be reported as significant at .1 as we are doing multiple tests.

†These variables comprised the discriminant function that identified factors that differentiated between continuation and no continuation. This is an analysis of variance on those factors.

studies tended not to talk very often to math teachers. They did not have to like a teacher to take a class; they did not care if the teacher were male or female, and they rated their teachers higher on being professional. Their decision about taking the math classes was more related to the subject matter than to the teacher. If they needed the next math class to complete their plans they took it. These students more often say their career plans are linked to taking more math courses.

The students not continuing in math studies reported more difficulty with mathematics, more math anxiety, and fewer positive experiences. They also tested lower on the space relations test. Interestingly, they did not score lower on the geometry test.

Women who were continuing in math studies received more support from their fathers and mothers to take math courses and these parents had higher expectations for them regarding college. Peers, counselors or school programs did not make a difference in whether male or female students continued in math studies.

Summary

The factor most often found to differentiate the students continuing in mathematics from those who are not, identified from the student questionnaire, student ratings and test data, is parental expectations and support in taking advanced mathematics. Men were more influenced by fathers while women were influenced by mothers and fathers. Parental influence to take math was linked to career plans. Prior research suggests that parental encouragement of women to enroll in advanced math classes is crucial but often absent (Aiken, 1972a; Haven, 1971; Fennema and Sherman, 1977a). Our data suggest that parents are perhaps the most important factor for women as well as men in continuing with math studies.

Men continuing in mathematics were more likely to talk with their math teachers than were women who were continuing. However, women continuing rated their math teachers as being more professional than did those not continuing. They also said they would take a class from a teacher they did not like. Nonetheless, teacher influence was not one

of the most highly rated influences on students' decisions to continue in math studies. Nor did men and women students credit peers, counselors, or school programs as important in affecting their math enrollment decisions.

Women who were continuing in math studies had more spatial ability, more positive feelings about mathematics, and less anxiety. Thus, we must conclude that attitude and aptitude are factors in students' continuing in math studies. However, actual achievement on the geometry test was not related to the decision to continue or not continue.

Other researchers have reported that women tend to underestimate their intellectual abilities and lack self-confidence, resulting in math anxiety (Ernest, 1976; Levine, 1976). However, the women in this study who planned to continue in math studies reported that they like mathematics, they are good at it, and it is necessary for careers they have chosen. This population of women responded differently than those described by Ernest, 1976; Fennema and Sherman, 1977b. They did not perceive mathematics as a male domain.

The results of this study suggest that parents should be made more aware of their influence in their children's decision making processes. Encouragement to consider careers that require higher mathematics and exposure to careers in science and math are related to women's decision to enroll in higher math classes.

These findings should be made available to inservice secondary teachers, school counselors, and parent groups. Each of these role groups can be influential, especially at the junior high school level in encouraging young women to consider careers in math and science. Young women should be encouraged to include advanced math when they plan their high school curricula. In addition, instructors in schools of education should make preservice teachers aware of their responsibility to be supportive of young women to select a school curricula that will permit careers in math and science.

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